Operative Techniques in Thoracic and Cardiovascular Surgery

Robotic Lobectomy: Left Upper Lobectomy

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The use of robotics for lung resection has increased significantly over the past several years. We favor a completely portal 4-arm approach. Left upper lobectomy, which many believe is the most complex of the 5 lobectomies, is well-suited for robotic assistance. Port placement and conduct of the operation are described. Robotic left upper lobectomy can be done with minimal morbidity and extremely low perioperative mortality, with similar postoperative and oncological results when compared with video-assisted thoracoscopic surgery lobectomy.
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Introduction

Minimally invasive lobectomy has traditionally been performed using video-assisted thoracoscopic surgery (VATS) techniques. The first robotic lobectomies were reported in 2003 by Morgan et al and Ashton et al.[1,2] Since then, the use of robotic technology for lobectomy has become increasingly common. In 2015, over 6000 robotic lobectomies were performed in the United States. Many surgeons believe that left upper lobectomy is the most challenging of the 5 lobectomies, given the greater number of arterial branches to the lobe and the degree of variability in terms of the anatomy.

The evaluation of a patient for robotic lobectomy includes the typical studies for patients undergoing lung resection. For patients with suspected or biopsy-proven lung cancer, whole-body positron emission tomography/computed tomography scan is currently the standard of care. Pulmonary function testing including measurement of diffusion capacity (diffusing capacity of the lungs for carbon monoxide) and spirometry is routine. Mediastinal staging is performed with endobronchial ultrasound-guided fine-needle aspiration biopsy or mediastinoscopy.

VATS lobectomy is safe in patients with a predicted postoperative forced expiratory volume or diffusion capacity (diffusing capacity of the lungs for carbon monoxide) of <40% of predicted.[3] We consider robotic lobectomy feasible in these patients as well. At present, we view vascular invasion, locally invasive T4 lesions, Pancoast tumors, and massive tumor (>10 cm) as contraindications for a robotic approach to lobectomy. The need for reconstruction of the airway, chest wall invasion, presence of induction chemotherapy or radiation, prior thoracic surgery, and hilar nodal disease are not contraindications for robotic-assisted lobectomy for experienced surgeons.

We use a completely portal approach that involves all 4 arms of the da Vinci Si or Xi robot. Port placement for robotic left upper lobectomy is shown in Figure 1. For the da Vinci Si system, we use two 8-mm ports (left and right robotic arm ports), a 12-mm port (camera), and one 5-mm port (fourth robotic arm port); for the Xi system, all the ports are 8-mm ports. We also use a 12-mm assistant port that can be used for stapling and exchange of items such as rolled-up sponges and vessel loops. The assistant port is also important in case sudden or catastrophic bleeding occurs. For a left upper lobectomy, the ports are generally placed in the seventh intercostal space. The fourth robotic arm is located 2-3 cm from the spine; the right robotic arm port is located 10 cm away from that port; the camera port is located 9 cm from the right robotic arm port; and the left robotic arm is located 9 cm away from the camera port. The port locations are marked beforehand, although slight changes to these locations are often necessary once the intrathoracic anatomy is visualized. The assistant port is a 12-mm port inserted just superior to the diaphragmatic fibers and triangulated between the camera and the left robotic arm ports. We insufflate the thoracic cavity with warmed, humidified carbon dioxide, which decreases the size of the lung and pushes the diaphragm inferiorly. We administer a subpleural paravertebral block using 0.25% bupivacaine with epinephrine. This technique is done with the camera placed anteriorly (the future left robotic arm) and with a view of the spine and the aorta. The surgeon inserts a 21-gauge needle from the patient's back and injects an anesthetic between the ribs, near the intercostal nerve, ideally without puncturing the pleura itself.

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Once the ports have been secured, the Si system robot is steered at a 15° angle over the patient's shoulder and the ports are docked to the robotic arms (Fig. 2). For the Xi system, the robot can approach the operating room table perpendicular to the patient and the beam is rotated to the proper position. The robotic instruments we use most commonly for robotic lobectomy are a bipolar curved-tip dissector in right robotic arm, a cadiere grasper in the left robotic arm, a lung grasper (Si system), or a tip-up fenestrated grasper (Xi system) in the fourth robotic arm. Generally speaking, neither the location of the camera nor the location of the fenestrated grasper need to be changed during the case.

Conduct of Robotic Left Upper Lobectomy

The order of steps in terms of structures isolated or transected tends to be the same for robotic upper lobectomy from case to case (Figs. 3-16). Occasionally, factors such as the location and size of the tumor and variations in anatomy dictate that the order of steps be switched. The surgeon should maintain flexibility in terms of dividing structures if or when they are accessible, with the caveat that dividing the vein before arterial branches can lead to congestion of the lung and increased bleeding.